Seasonal distribution of herbage mass and nutritive value of Prairiegrass (*Bromus catharticus* Vahl)

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Abstract

A reliable supply of herbage is a crucial feature of forage-based livestock systems. Forage resources with winter-active growth habits can help extend the growing season in early spring and late autumn in regions with mild-winter conditions while drought- and heat-tolerant plants help meet herbage needs during summer in humid temperate regions. The prairiegrass (*Bromus catharticus*, Vahl) cultivars, Grassland Dixon and Grasslands Lakota, provide resistance to foliar disease and cold in addition to sustained productivity when soil moisture is low, and could be useful over a wide range of growing conditions. The cultivars were sown in spring or summer to determine seasonal distribution of productivity and nutritive value of herbage grown in a cool-temperate region. Stands established rapidly regardless of sowing time or cultivar and were virtually pure prairiegrass once plants were well-established. Stand composition of broadcast sowings tended to be stable in subsequent growing seasons, whereas the amount of prairiegrass varied in no-till stands. In the growing seasons after establishment, cumulative dry matter (DM) yield of Lakota was similar regardless of when it was sown, whereas DM yield of Dixon differed with sowing time and was less in spring- than summer-planted stands. Rapid stand establishment, significant late-season yield, consistent concentrations of crude protein, non-structural carbohydrate and total digestible nutrients in herbage, and dominance of sward composition, suggest that prairiegrass cultivars, Dixon and Lakota, are excellent resources for forage-based livestock production systems in humid temperate conditions.

Keywords: botanical composition, crude protein, forage production, nutritive value, total non-structural carbohydrate

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Introduction

A reliable supply of herbage with predictable nutritive value is a crucial feature of forage-based livestock production systems. Strategic management, such as timing of grazing or mowing events, nutrient inputs, and stockpiling, or deferring the use of accumulated herbage, can improve the distribution of herbage production within a year. Other management options include the creation of swards using plant resources with seasonal growth patterns and nutritive value that meet the requirements of the production system. For example, in humid temperate regions, species with winter-active growth can extend the interval of production by starting growth early in spring and continuing later in autumn in regions where mild-winter conditions prevail, while drought- and heat-tolerant plants can help meet the needs for herbage mass during summer.

Prairiegrass (*Bromus catharticus*,Vahl, synonymous with *B. willdenowii,* Kunth, and *B.unioloides*, Hum., Bonpl., *et* Kunth), also known as rescuegrass (see Table 1 for a listing of scientific descriptors and cultivars), originated in the Pampas of South America and was introduced and used for winter pasture in the south-eastern United States prior to the middle of the nineteenth century (Newell, 1973). Prairiegrass grows during the cooler periods of the year and is somewhat drought-tolerant, giving it the ability to be productive when traditional cool-temperate pasture growth is slow (Burgess *et al*., 1986). Prairiegrass can occur as a weedy grass in lawns and stands of *Medicago sativa* L., and can be oversown in bermudagrass (*Cynodon dactylon* L.) pastures (Green *et al*., 2001).

Agronomic information on the growth and productivity of prairiegrass is limited in comparison to what is known about other grasses of temperate origin. A comprehensive series of papers was published by Hume (1990, 1991a,b,c,d), detailing the morphology and physiology of *B. willdenowii* Kunth growing in field and controlled environmental conditions. Most of the information on the culture and production of improved cultivars, such as Grasslands Matua (Rumball, 1974),

Table 1 Nomenclature used to describe prairiegrass within the genus *Bromus*.

Scientific name	Common name and cultivar	Source
Bromus willdenowii	Prairiegrass cv. Grasslands Matua	Bell and Ritchie (1989); LaCasha *et al.* (1999); Fulkerson *et al.* (2000)
Bromus unioloides	Prairiegrass cv. Priebe	Cameron *et al.* (1969); Grof *et al.* (1969); Rumball *et al.* (1972)
B. unioloides/B. willdenowii	Prairiegrass cv. Grasslands Matua	Jung *et al.* (1994)
Bromus cartharticus	Prairiegrass cv. Grasslands Matua	Piniero and Harris (1978a,b); Rumball (1974); Vartha (1977)
B. cartharticus	Prairiegrass cv Grasslands Dixon	Rumball and Miller (2003a)
B. cartharticus	Prairiegrass cv. Grasslands Lakota	Rumball and Miller (2003b)
Bromus carinatus	California/mountain bromegrass	Rumball *et al.* (1972)
Bromus erectus	Upright bromegrass	Rumball *et al.* (1972)
Bromus firmior		Rumball *et al.* (1972)
Bromus inermis	Smooth bromegrass	Rumball *et al.* (1972)
Bromus marginatus	Mountain bromegrass cv. Ness	Rumball *et al.* (1972)
Bromus popovii		Rumball *et al.* (1972)
Bromus riparius	Meadow bromegrass	Rumball *et al.* (1972)
Bromus sitchenis	Blizzard or bosir bromegrass	Rumball *et al.* (1972)
Bromus stamineus	Grazing bromegrass	Rumball *et al.* (1972)
Bromus uruguayensis		Rumball *et al.* (1972)
Bromus unioloides × *Bromus haenkeanus*	Prairiegrass	Rumball *et al.* (1972)
B. unioloides	Prairiegrass/rescuegrass	Rumball *et al.* (1972)

Grasslands Dixon (Rumball and Miller, 2003a), and Grasslands Lakota (Rumball and Miller, 2003b), originated in New Zealand, with most of the published data relevant for US growing conditions limited to Matua. Bennett (1973) provided a general description of rescuegrass for use in the south-eastern United States and parts of the Pacific Coast where the short-lived, winter-active plants require ample nutrient input to sustain production.

Defoliation based on leaf appearance rates enables prairiegrass plants to achieve a balance between shoot and root production (Slack *et al.*, 2000), and nutritive value (Turner *et al.*, 2006c). Balancing regrowth interval with herbage use sustained available herbage production (Turner *et al.*, 2006a) and enabled plants to tolerate defoliation and persist in pastures (Jatimliansky *et al.*, 1997). Careful autumn management, allowing Matua prairiegrass stands the opportunity to reseed in late summer, increased their persistence (Jung *et al.*, 1994). Stockpiling Matua for grazing in autumn seriously compromised subsequent stand persistence (Hall *et al.*, 1998). While Matua prairiegrass grew vigorously until mid-November in central Appalachia (Belesky and Stout, 1994), persistence was compromised by disease and inappropriate mowing management.

New prairiegrass cultivars capable of tolerating warm air temperatures, relatively low soil-water availability (Grasslands Dixon) (Rumball and Miller, 2003a), or low air temperatures (Grasslands Lakota) (Rumball and Miller, 2003b), provide materials better suited to a wider range of growing conditions occurring in humid temperate continental climates. Both of these cultivars have less susceptibility than Matua to foliar disease (Rumball and Miller, 2003a,b). The new cultivars could prove useful components of forage-based livestock production systems by extending the geographic range of the use of prairiegrass through improved herbage production in spring and autumn, or mid-summer when gaps in production typically occur in temperate-region pastures. The premise was that prairiegrass established in late summer would have greater total production because of rapid establishment in cool autumn conditions compared with stands established in spring and that response would be mediated, in part, by cultivar. The overall objective was to determine the distribution of productivity, and nutritive value, for Grasslands Dixon and Grasslands Lakota when sown in either spring or summer.

Materials and methods

Plots of prairiegrass cultivars, Grasslands Dixon and Grasslands Lakota (hence referred to as Dixon or Lakota), were established on an upland site (<5% slope) of Clymer channery loam (coarse-loamy, siliceous, active, mesic Typic Hapludult) soil on the Allegheny Plateau in southern West Virginia (37°46′N; 81°00′W; 870 m a.s.l.). Glyphosate [*N*-(phosphono-methyl) glycine] at 2·5 kg a.i. ha^{-1} and tillage of the killed sward material were used to eliminate existing species including a number of grasses, forbs, and legumes. Soil fertility supplied moderate amounts of P (about 15 kg ha^{-1}) and ample K (about 250 kg ha^{-1}), at an initial pH of 7·03 in the surface 15 cm of soil. Summer sowings were established in late June 2003 and 2004 and spring sown-stands in mid-May 2004. The cultivar main plots (3 m × 10 m) were subdivided to accommodate multiple harvest strips (1 m × 3 m). Plots were hand-sown on the soil surface, or direct-drill sown at a depth of 20 mm, at the same rate of 45 kg prairiegrass seed ha^{-1}. The site was compacted mechanically after sowing to improve seed-to-soil contact. About 400 kg ha^{-1} of a N, P, and K (19-19-19) fertilizer was applied to each plot at sowing, with an additional 35 kg N ha^{-1} applied after each harvest in the growing season.

Harvests began between 60 and 70 d after sowing (DAS) for spring or summer-planted swards. Samples for yield of dry matter (DM) were collected every 28 d after the initial harvest. Harvests were suspended when growth ceased or when a mean sward height of 25 cm was not achieved. Harvests were made with a rotary mower equipped with a collection bag and a residual sward height of 10 cm was left. Botanical composition of the sward was determined visually prior to clipping using a point-intercept method (Warren-Wilson, 1959). Herbage was dried at 60°C in a forced-draught oven, weighed to determine the DM content and ground to a 1-mm particle size for chemical analyses. Nitrogen concentration was determined by total combustion of dry plant tissue (Carlo Erba EA 1108 CHNSO analyzer; Fisons Instruments, Beverly, MA, USA), and expressed as crude protein concentration (CP; g total N $kg^{-1} \times 6{\cdot}25$). Non-structural carbohydrates (TNC) were determined by an automated hydrolysis method (Denison *et al.*, 1990). Total digestible nutrients (TDN) were calculated from estimated metabolizable energy (ME) values (NRC, 1996) derived from acid-detergent fibre (ADF) concentrations, expressed as a percentage (MAFF, 1987), using the following equations;

$$\text{ME derived from ADF} : \text{ME}(\text{MJ kg}^{-1}\text{DM}) = 15{\cdot}3 - 0{\cdot}153\ \text{ADF};$$

$$\text{TDN derived from ME} : \text{TDN } (\%) = [((\text{ME}/4{\cdot}184)/0{\cdot}82)/4{\cdot}409] \times 100.$$

Statistical analyses

The experiment was analysed as a randomized complete block with three replicates, with two sowing times, two cultivars and two seeding methods as main plots. Data for cumulative DM yield of a whole plot, sward composition, TNC and CP concentrations are shown relative to days after sowing. Instantaneous growth rate (IGR), CP and TNC concentrations were analysed as a randomized complete block design with repeated measures analysis using SAS PROC-MIXED procedures (Littell *et al.*, 1996). Swards were considered as establishing (swards up to 120 d after sowing) or established (swards more than 120 d after sowing or growing in subsequent years) and were analysed separately for each sowing time. Sowing times were analysed separately because this was a significant source of variation ($F_{d.f.,\ 237} = 175{\cdot}83$; $P > F < 0{\cdot}001$) in the model. Data on cumulative DM yields were modelled using Gompertz growth curves and SAS-NLIN procedures, with instantaneous growth rates computed from first derivatives of equations representing the modelled data. Data on sward composition were analysed by multiple non-linear regression procedures (PROC NLIN) (Latour and Thompson, 1997).

Results and discussion

Weather conditions

Early season precipitation (April–July) was low in 2003 and high in 2004 relative to the 30-year mean (Figure 1). Precipitation during the establishment phase of summer-sown swards, represented by the period from July to October, was about 345 mm in 2003 and 495 mm in 2004. Precipitation occurring during the spring establishment phase, represented by the period from April to July, was about 650 mm in 2004. Precipitation for the same interval in 2005 was 480 mm. Minimum and maximum air temperatures for all years were similar to, or slightly greater than, the 30-year means. Mean monthly air temperatures in autumn tended to be greater than the 30-year means. The relative difference in precipitation between years, prior to and during sward establishment, could contribute to variation in establishment success and annual herbage production. Short-term variation in precipitation during the growing season was reflected in individual harvest yields (data not shown).

Botanical composition

During establishment, swards of spring- and summer-sown Dixon or Lakota prairiegrass comprised a mixture of species arising from the soil seed bank but the swards were essentially pure prairiegrass by the last harvest of the season (Figure 2). Sward composition varied with sowing time and method. Conditions associated with summer sowings were probably more favourable to prairiegrass than those occurring in spring, when conditions might favour germination and growth of other plant species in competition with the establishing prairiegrass seedlings.

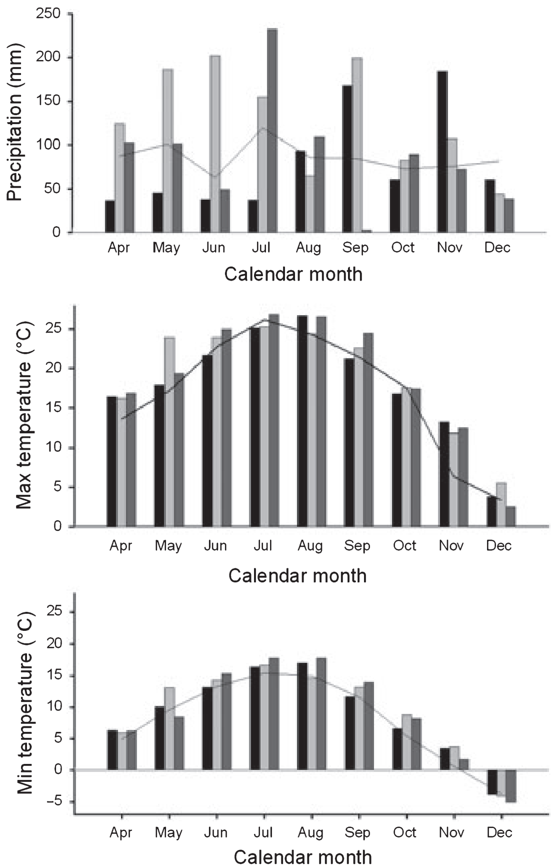

Figure 1 Monthly (April–December) maximum and minimum air temperatures in 2003 (solid boxes), 2004 (tinted boxes) and 2005 (grey-coloured boxes), and 30-year mean (solid lines) precipitation, at Beckley, West Virginia.

Dixon and Lakota established at similar rates within each sowing time (Table 2) in terms of stand composition expressed as a function of days after sowing. Stands established rapidly (Figure 2) despite differences in precipitation in the respective periods after sowing. The proportion of prairiegrass was influenced by sowing method during establishment with broadcast and no-till summer-sown prairiegrass reaching maximum population frequency rapidly, irrespective of the cultivar. There was a higher proportion of prairiegrass in broadcast-sown than in no-till swards at the initial harvest after sowing (Figure 2). Despite differences, broadcast-sown and no-till sowings had similar proportions of prairiegrass by about 120 d after sowing. The proportion of prairiegrass in established broadcast-sown swards did not change with time whereas it did in no-till stands. Lakota swards tended to be more variable in composition than Dixon swards during establishment and in subsequent growing seasons. In all instances, the increase in the proportion of either Dixon or Lakota prairiegrass was accompanied by a decline in broad-leaved weeds and grasses other than prairiegrass (data not shown). Bare or open areas in established stands were minimal (proportionately <0·05).

Yields of DM

The cumulative DM yields of spring- and summer-sown prairiegrass swards were influenced by sowing method and DM yields varied with harvest date during the growing season. This occurred regardless of whether the swards were establishing, or were well-established and growing in years subsequent to establishment. Summer-sown swards in the establishment phase were influenced by interactions of cultivar with sowing method and time, whereas established swards differed in productivity with cultivar, time, and the interaction of cultivar with sowing method and time. Once swards became established, following the first winter after sowing, DM yields for summer and spring-sown Lakota were similar (Table 3). Yields of DM of established swards of Dixon differed with sowing time with greater DM yields obtained with summer-sown than spring-sown swards. This might reflect, in part, greater productivity associated with vernalized plants, represented by established plants in this experiment, as noted by Hume (1991c). During the establishment phase of spring-sown stands, Dixon had higher DM yields than Lakota. Once established, DM yields were similar for Dixon and Lakota. Establishing swards of no-till Lakota tended to have higher DM yields than Dixon when planted in summer. The increased DM yields obtained with Lakota sown in summer might be a function of a more sustained growth during autumn. Once established, Dixon tended to be more productive than Lakota planted in summer.

Yields of DM of broadcast-sown swards were greater than that of no-till swards, regardless of the time of sowing. The difference between sowing methods appeared to be greater for Dixon than Lakota prairiegrass. Distinct rows were visible in the no-till swards during the establishment phase. The presence of distinct rows for both cultivars continued in the subsequent years when swards were well-established and growing vigorously. The persistence of distinct rows of prairiegrass in the no-till swards probably contributed to differences in botanical composition and DM yields compared with broadcast-sown swards. Gaps between rows provided opportunities for encroachment by weeds while crowding within the row may have been the reason for the lower DM yields because of competition among prairiegrass plants. Both cultivars tolerated clipping at 4-week intervals during establishment in either spring or summer and had greater DM yields in

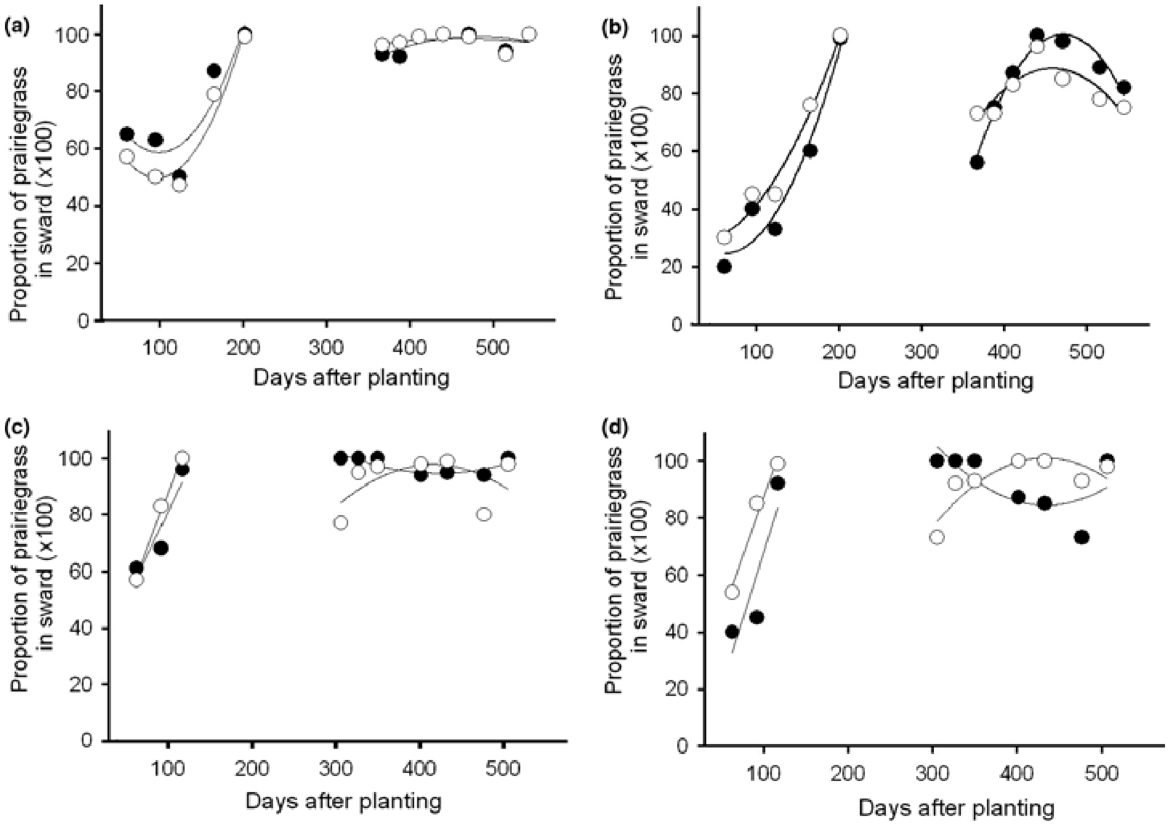

Figure 2 Relationship between days after sowing and the proportion of prairiegrass in the swards for establishing and established swards of prairiegrass cultivars, Dixon (solid circles) and Lakota (open circles), sown in (a) spring using a broadcast method, (b) spring using a no-till method, (c) summer using a broadcast method, and (d) summer-sown using a no-till method. Values, representing the number of contacts, expressed as a proportion × 100, are the means of three replicates and 2 years.

subsequent growing seasons, supporting previous results obtained with prairiegrass grown in mixture with a brassica hybrid [turnip (*Brassica campestris* var. rapa L.) × Chinese cabbage (*B. pekinensis* (Lour.) Rupr.)] (Belesky and Ruckle, 2006).

Summer-sown prairiegrass was not infected by foliar disease in the following spring, regardless of cultivar (data not shown). No-till and spring-sown swards tended to have more foliar disease than broadcast-sown or summer-sown swards (data not shown). Herbage from the swards was removed by cutting and an additional 25 kg N ha^{-1} was applied in the late spring of 2005 to help alleviate the foliar disease problem (W. Rumball, personal communication).

The seasonal pattern of production represented by IGR as a function of day-of-year, differed for sowing method and cultivar during the establishment phase for spring- and summer-sown swards (Figure 3). The IGR varied for establishing swards in terms of when maximum rates occurred and the magnitude of rates achieved. The IGR pattern of establishing summer-sown swards suggests that high and sustained autumn production is possible for Dixon and Lakota prairiegrass. Well-established stands varied much less in terms of when maximum productivity occurred and the maximum rate achieved during the season. Maximum IGR of established swards ranged from 37 to 43 kg ha^{-1} d^{-1} around calendar day 170. The maximum occurred at about the same time regardless of the sowing season, method, or cultivar.

Nutritive value

Harvest date influenced CP and TNC concentrations (Table 4) of the herbage of establishing spring- or summer-sown swards of Dixon and Lakota prairiegrass (Figures 4 and 5). Concentrations of TNC tended to be greater in spring and autumn than in mid-season (Figure 4) and were similar to trends reported by Turner *et al.* (2006a). The CP concentrations tended to increase in autumn relative to earlier in the growing season, a finding which supports observations reported

Table 2 Regression equations of prairie grass as a proportion of the sward for cultivars Dixon (Y_D) and Lakota (Y_L) in spring or summer-sown prairiegrass swards as a function of time (days after sowing, DAS) in establishing (N) or established (E) swards.

Prairiegrass as a proportion of sward (×100)		Model values *d.f.*	R^2	*F*	*P*
Summer broadcast					
N	$Y_D = 6{\cdot}37 \times 10^{-1}(\mathrm{DAS}) + 17{\cdot}21$	8	0·87	5·12	*
N	$Y_L = 7{\cdot}99 \times 10^{-1}(\mathrm{DAS}) + 7{\cdot}56$	8	0·99	13·21	**
E	$Y_D = -4{\cdot}31 \times 10^{-1}(\mathrm{DAS}) + 5{\cdot}09 \times 10^{-4}(\mathrm{DAP})^2 + 185{\cdot}77$	20	0·66	3·20	NS
E	$Y_L = 9{\cdot}25 \times 10^{-1}(\mathrm{DAS}) - 1{\cdot}11 \times 10^{-3}(\mathrm{DAP})^2 - 94{\cdot}66$	20	0·27	1·94	NS
Summer no-till					
N	$Y_D = 9{\cdot}42 \times 10^{-1}(\mathrm{DAS}) - 26{\cdot}41$	8	0·79	7·41	*
N	$Y_L = 8{\cdot}40 \times 10^{-1}(\mathrm{DAS}) + 3{\cdot}21$	8	0·97	12·65	**
E	$Y_D = -1{\cdot}09(\mathrm{DAS}) + 1{\cdot}25 \times 10^{-3}(\mathrm{DAS})^2 + 320{\cdot}96$	20	0·50	2·51	NS
E	$Y_L = 1{\cdot}19(\mathrm{DAS}) - 1{\cdot}37 \times 10^{-3}(\mathrm{DAS})^2 - 156{\cdot}51$	20	0·76	6·57	**
Spring broadcast					
N	$Y_D = -8{\cdot}39 \times 10^{-1}(\mathrm{DAS}) + 4{\cdot}24 \times 10^{-3}(\mathrm{DAS})^2 + 100{\cdot}12$	14	0·84	12·16	**
N	$Y_L = -9{\cdot}12 \times 10^{-1}(\mathrm{DAS}) + 4{\cdot}71 \times 10^{-3}(\mathrm{DAS})^2 + 93{\cdot}89$	14	0·95	7·34	*
E	$Y_D = 5{\cdot}04 \times 10^{-1}(\mathrm{DAS}) - 5{\cdot}24 \times 10^{-4}(\mathrm{DAS})^2 - 21{\cdot}89$	20	0·43	4·48	*
E	$Y_L = 1{\cdot}80 \times 10^{-1}(\mathrm{DAS}) - 1{\cdot}96 \times 10^{-4}(\mathrm{DAS})^2 + 56{\cdot}97$	20	0·06	0·75	NS
Spring no-till					
N	$Y_D = 4{\cdot}42 \times 10^{-1}(\mathrm{DAS}) + 3{\cdot}62 \times 10^{-3}(\mathrm{DAS})^2 + 38{\cdot}02$	14	0·95	20·89	***
N	$Y_L = -1{\cdot}04 \times 10^{-1}(\mathrm{DAS}) + 2{\cdot}26 \times 10^{-3}(\mathrm{DAS})^2 + 29{\cdot}27$	14	0·98	10·50	***
E	$Y_D = 3{\cdot}70(\mathrm{DAS}) - 3{\cdot}93 \times 10^{-3}(\mathrm{DAS})^2 - 769{\cdot}98$	20	0·97	13·57	***
E	$Y_L = 1{\cdot}98(\mathrm{DAS}) - 2{\cdot}16 \times 10^{-3}(\mathrm{DAS})^2 - 363{\cdot}95$	20	0·70	4·95	*

NS, not significant; *$P < 0{\cdot}05$; **$P < 0{\cdot}01$; ***$P < 0{\cdot}001$.

Table 3 Cumulative dry matter yield (kg ha^{-1}) and analysis of variance for the same variable of prairiegrass as a function of sowing time (spring or summer), sowing method (broadcast, BC; no-till, NT), and cultivar (Dixon or Lakota). Dry matter yields are presented for establishing and established stands (represented as maturity). Values are the means of three replicates and 2 years. Standard errors of mean are given in parentheses.

	Summer				Spring			
	Establishing		Established		Establishing		Established	
	BC	NT	BC	NT	BC	NT	BC	NT
Dixon	1489 (311)	886 (253)	7050 (856)	6061 (715)	4037 (259)	2222 (509)	5721 (693)	5019 (667)
Lakota	1222 (454)	1294 (419)	5436 (689)	5309 (679)	3410 (690)	1521 (439)	5755 (329)	5229 (408)

Analysis of variance	Summer $F_{d.f.=112}$	Summer $P > F$	Spring $F_{d.f.=136}$	Spring $P > F$
Source of variation				
Cultivar	1·37	NS	0·33	NS
Sowing method	0·01	NS	12·76	***
Maturity	44·21	***	44·57	***

NS, not significant; ***$P < 0{\cdot}001$.

There were no statistically significant interactions among main effects.

by Hall *et al*. (1996) that prairiegrass can maintain a relatively high nutritive value late in the growing season, allowing greater flexibility in use. The pattern of CP accumulation was associated with time of sward establishment, and whether the sward was growing in years subsequent to the establishment year or not

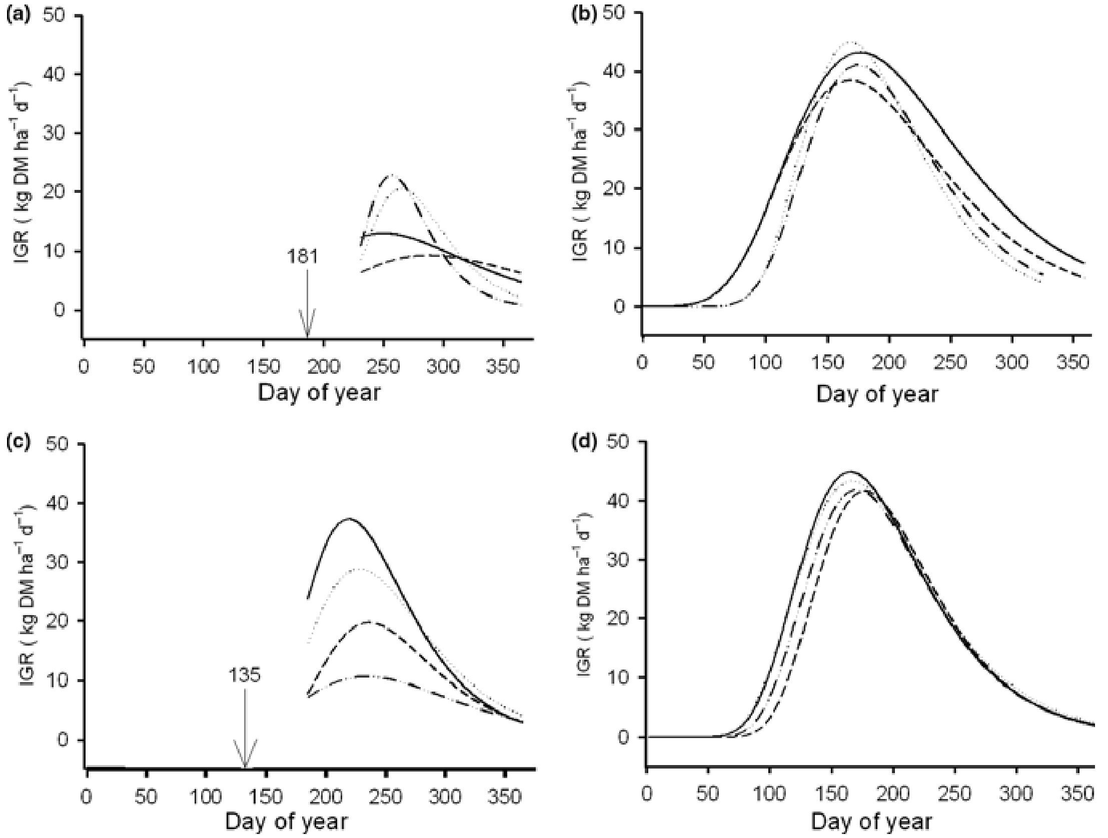

Figure 3 Relationships between day of year and instantaneous growth rates (IGR) of (a) establishing swards sown in Spring, (b) established swards sown in spring, (c) establishing swards sown in summer, and (d) established swards sown in summer for the broadcast method of sowing on prairiegrass swards with Dixon (solid lines) and Lakota (dotted lines) cultivars, no-till method of sowing on prairiegrass swards with the Dixon cultivar (dashed lines) and no-till method of sowing on prairiegrass swards with the Lakota cultivar (dotted/dashed lines). Values on instantaneous growth rates were derived from the Gompertz growth model of cumulative dry matter yield. Sowing date (day of year) indicated for spring and summer-sown swards.

Table 4 Analysis of variance for the influence of cultivar (Dixon or Lakota), maturity (established or establishing sward), and harvest date (within a growing season) and the interactions for spring-sown (spring) or summer-sown (summer) prairiegrass on total non-structural carbohydrate (TNC) and crude protein (CP) concentrations of herbage.

	TNC		CP	
	Summer	**Spring**	**Summer**	**Spring**
Cultivar (C)	*	**	***	***
Maturity (M)	***	***	***	NS
Harvest date (HD)	***	***	***	***
C × M	NS	NS	NS	NS
C × HD	***	NS	***	***
M × HD	NS	NS	NS	NS
C × M × HD	NS	NS	NS	NS

NS, not significant; *$P < 0{\cdot}05$; ***$P < 0{\cdot}001$.

(Figure 5). The CP and TNC concentrations of spring-sown swards were influenced by cultivar while cultivar interacted with harvest date to influence CP and TNC concentrations of summer-sown swards of Dixon and Lakota prairiegrass. The influence of harvest date reflects the variation in short-term precipitation and temperature patterns interacting with plant development and chemical composition.

Sowing method had no influence on TDN concentration. Once established, the TDN concentration of Dixon and Lakota prairiegrass was stable across the growing season. The TDN concentration ranged from 0·63 to 0·67 throughout the experiment and was comparable with mid- to high-quality alfalfa (*Medicago sativa* L.) hay (NRC, 1996). Despite variation in CP and TNC concentrations across the periods associated with establishing and established swards of prairiegrass, the

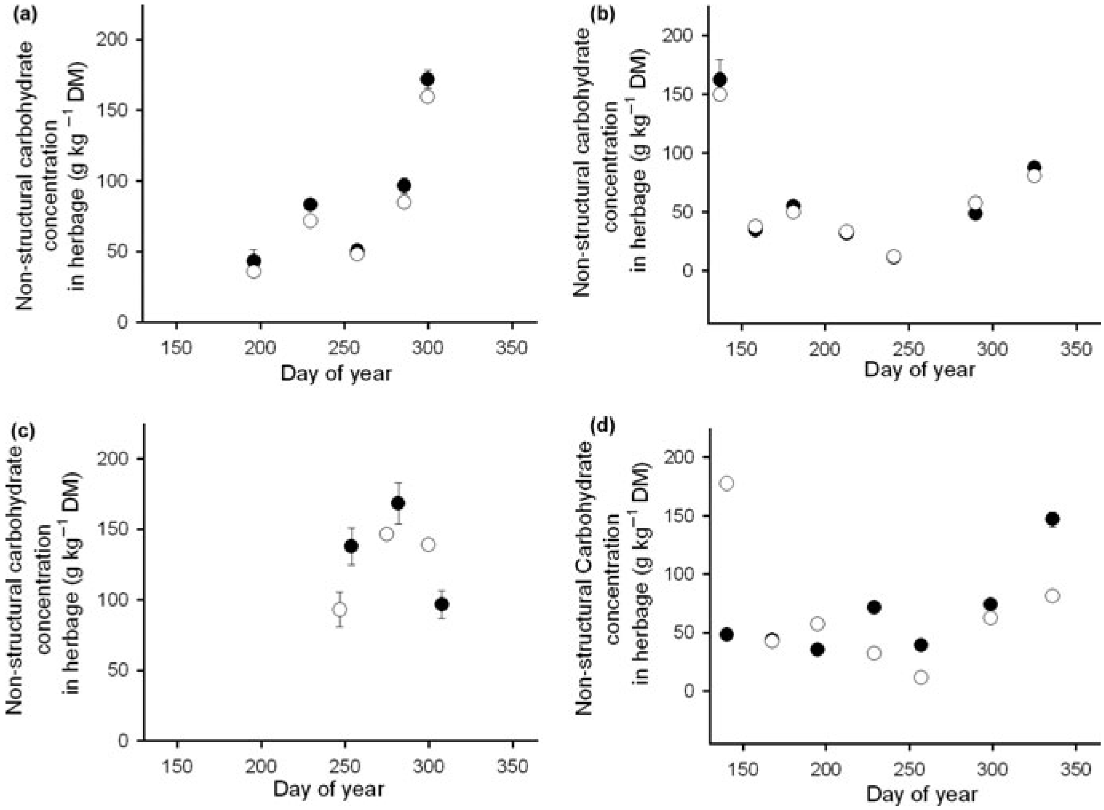

Figure 4 Relationships between days of year and concentrations of total non-structural carbohydrate (TNC) in herbage for (a) establishing swards sown in spring, (b) established swards sown in spring, (c) establishing swards sown in summer, and (d) established swards sown in summer, harvested from swards of cultivars Dixon (solid circles) and Lakota (open circles) prairiegrass. Vertical bars are standard errors of the mean.

stable TDN concentrations (Table 5), coupled with sustained DM yields, suggests that prairiegrass can provide a consistent supply of high-quality forage throughout the growing season. This premise is supported by Turner *et al.* (2006b), who reported that the ME concentration of prairiegrass coupled with superior DM yields relative to other cool-temperate forage grasses gave high ME yields ha^{-1}. Prairiegrass contributed a steady supply of TNC in a stockpiled, mixed stand of prairiegrass with a brassica hybrid (Belesky *et al.*, 2006).

Lakota prairiegrass has been found to produce liveweight gains comparable or superior to those achieved with endophyte- [*Neotyphodium coenophialum* (Morgan-Jones *et* Gams) Glenn, Bacon and Hanlin] infected tall fescue [*Lolium arundinaceum* (Schreb.) Darbysh.]. Yields of DM and CP concentrations were also similar to those of the tall fescue (A.O. Abaye, unpublished data). Prairiegrass displays an indeterminate growth habit so the variation in nutritive value associated with ontogeny and reproductive morphogenesis apparent in other cool-season grasses seems to be less noticeable in prairiegrass (Hume, 1991a). Once swards endured a winter dormant period, seasonal growth rates became somewhat less variable. These results may be attributable in part to defoliating prairiegrass swards at 4-week intervals coupled with responses associated with ontogenetic changes that arise from the progression of seasons.

Conclusions

Rapid establishment, strong late-season DM yield, consistently high CP, TNC, and TDN concentrations, and dominance in the sward suggest that the prairiegrass cultivars Dixon and Lakota are excellent resources for forage-based livestock production systems. Established swards of Dixon and Lakota had similar total DM yields and rates of growth, irrespective of cultivar, sowing time, or method. Swards established rapidly, regardless of sowing time or cultivar, and were virtually pure prairiegrass by the end of the year in which sowing

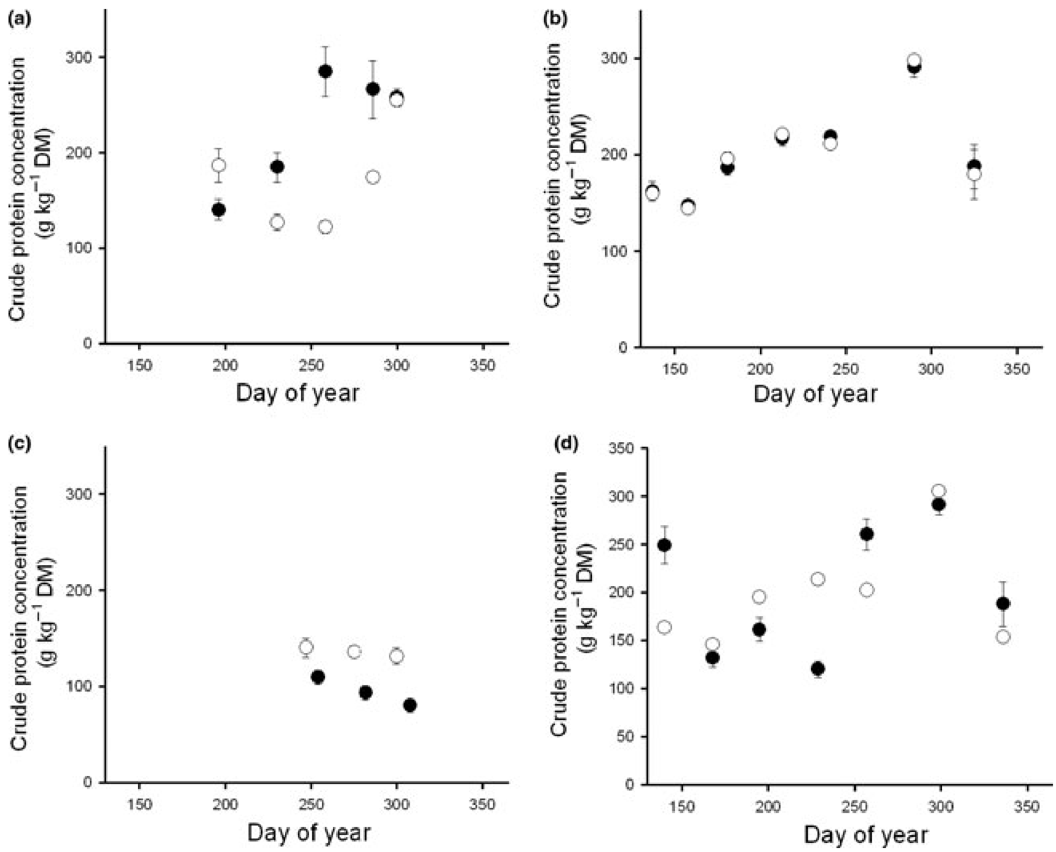

Figure 5 Relationships between days of year and concentrations of crude protein (CP) in herbage for (a) establishing swards sown in spring, (b) established swards sown in spring, (c) establishing swards sown in summer, and (d) established swards sown in summer, harvested from swards of cultivars Dixon (solid circles) and Lakota (open circles) prairiegrass. Vertical bars are standard errors of the mean.

Table 5 Concentration of total digestible nutrients (×100) of establishing and established swards of cultivars Dixon and Lakota of prairiegrass sown in spring or summer and analysis of variance of the same variable presenting significance of main effects and interactions of main effects. Standard errors of mean are in parentheses.

	Summer		Spring	
	Establishing	**Established**	**Establishing**	**Established**
Dixon	66·6 (0·72)	64·7 (0·30)	63·9 (0·36)	64·1 (0·20)
Lakota	64·7 (0·40)	65·6 (0·46)	64·1 (0·35)	66·1 (0·46)
Analysis of variance		**Summer**		**Spring**
Cultivar		NS		**
Maturity		NS		**
Harvest date		NS		NS

NS, not significant; ***P* < 0·01.

occurred. Broadcast sowing, when compared with no-till sowing, tended to result in a greater proportion of prairiegrass in the sward in the period shortly after sowing. Broadcast sowings also tended to be more stable in terms of sward composition in the second growing season, whereas the prairiegrass component of no-till stands varied, regardless of sowing time. Both cultivars tolerated repeated clipping at 4-week intervals with productivity comparable to and nutritive value surpassing that of the widely grown forage, tall fescue. While this experiment was conducted under mild, humid temperate conditions in the Appalachian Region of the United States of America, comparable results might be expected in similar climatic regions elsewhere.

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